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SILVICAL
*Characteristics*
OF...

# TAMARACK

(*Larix laricina*)

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## THE SILVICAL REPORTS

During 1907 and the following several years the U. S. Forest Service issued a series of silvical leaflets which covered the broad characteristics of a considerable number of major timber species. Since then much new knowledge has accumulated--some of it published in a variety of sources. There is also a considerable store of unpublished silvical information in the files of the forest experiment stations, the forest schools, and some other agencies. To compile this information systematically and make it available to foresters generally, the Lake States Forest Experiment Station is preparing reports on 15 individual species. Similar reports are being prepared by the other Federal forest experiment stations. When completed, these individual species reports will provide the basis for a comprehensive manual of silvics for the important trees of the United States, to be published by the U. S. Forest Service.

This report is one of the series being prepared by the Lake States Station. A preliminary draft was reviewed by several members of our own Station staff and by a number of well qualified staff members of other forest experiment stations, colleges, and universities; Federal, State, and Provincial forestry organizations; and forest industry. Their comments helped the author to make this report more complete, more accurate, and more up to date. An especially helpful review was submitted by T. J. Grisez of the Northeastern Forest Experiment Station.

Every effort has been made to ensure the accuracy and completeness of the information concerning the silvical characteristics of each species consistent with a brief treatment of the subject. We shall appreciate it, however, if any errors or omissions of important information are brought to our attention.

M. B. Dickerman

M. B. Dickerman, Director

Cover design: A typical forest-grown mature tamarack in northern Minnesota. Drawing represents leaves and cones.

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# SILVICAL CHARACTERISTICS OF TAMARACK

(Larix laricina (DuRoi) K. Koch)

by

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A small to medium-sized tree, tamarack was first described as a pine (Pinus laricina) by DuRoi in 1771. It was assigned to the genus Larix by Michaux in 1803 as L. americana. The name now used, L. laricina, was not adopted until 1873 (28).[2/] This species also includes the form native to Alaska which some botanists have called L. alaskensis Wight or L. laricina var. alaskensis (Wight) Raup. Other common names that have been used or are still used locally are eastern larch, American larch, hackmatack, and juniper (Maine).[3/] [4/]

## DISTRIBUTION

Tamarack has the widest range of any American coniferous tree. It is found farther north than either white spruce or black spruce, remaining tree-like where the latter species is prostrate and shrubby (35, 40). The tree occurs from Newfoundland and Labrador west along the northern limit of tree growth to Yukon Territory; thence south in the MacKenzie River drainage to northeastern British Columbia and central Alberta; thence east to southern Manitoba, southern Minnesota, southern Wisconsin, northeastern Illinois, northern Indiana, northeastern Ohio, and northern Pennsylvania, northwestern New Jersey, northern Connecticut, and Maine. It also occurs in interior Alaska, in the Yukon and Kuskokwim drainages, and locally in western Ohio, western Maryland and adjacent West Virginia, Long Island, and Rhode Island (28) (fig. 1).

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1/ Maintained by the Forest Service, U. S. Department of Agriculture, at St. Paul 1, Minn., in cooperation with the University of Minnesota.

2/ Underlined numbers in parentheses refer to literature cited, page 18.

3/ Correspondence with R. I. Ashman, Department of Forestry, University of Maine, May 3, 1956, on file at Lake States Forest Experiment Station.

4/ Correspondence with T. J. Grisez, Northeastern Forest Experiment Station, U. S. Forest Service, April 9, 1956, on file at Lake States Forest Experiment Station.

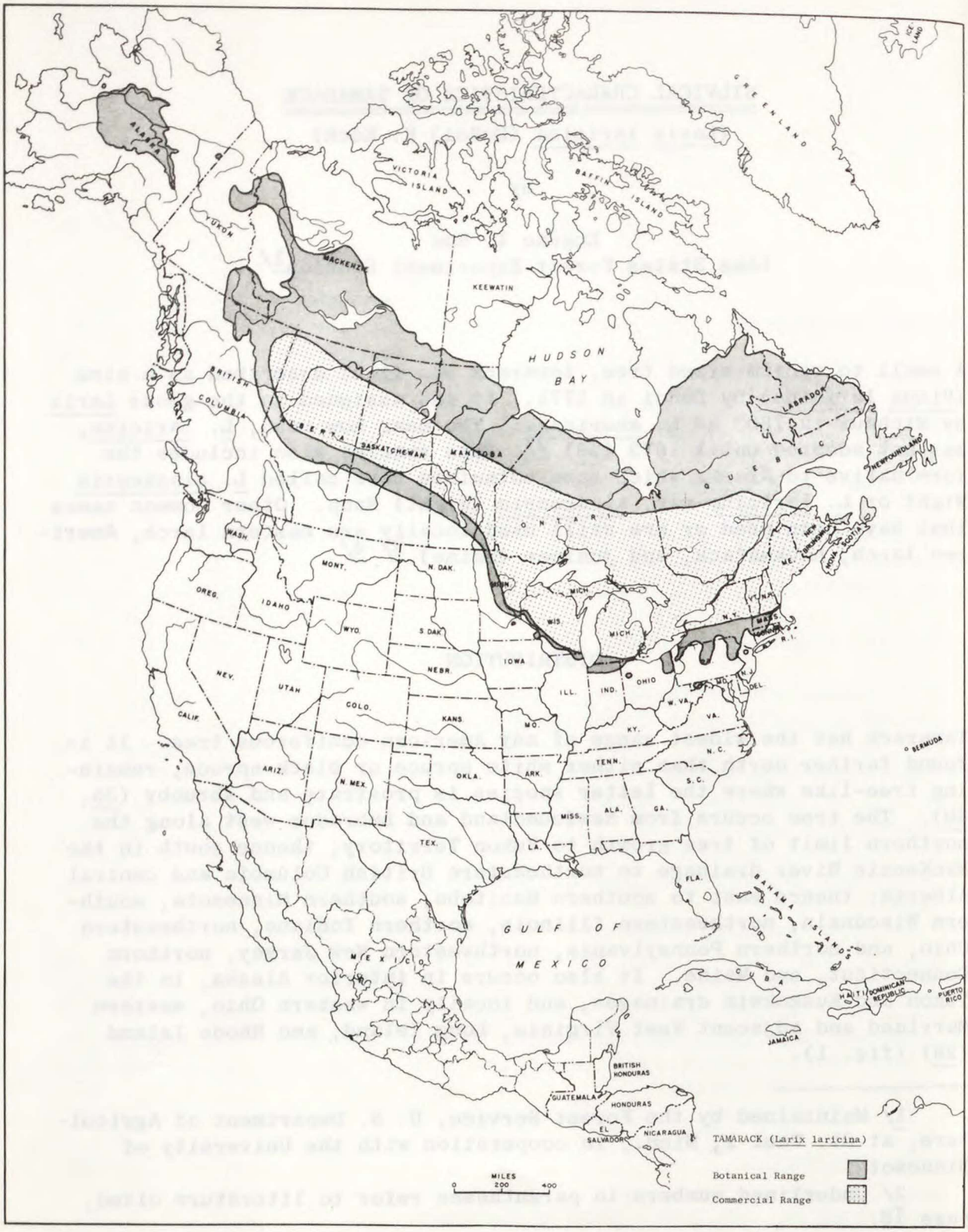


Figure 1.--Botanical and commercial range of tamarack.

The commercial range[5/] of tamarack, based on its development to usable size and its occurrence in stands, is believed to extend from Nova Scotia west through Maine, northern New England, Quebec, New York, Michigan, Wisconsin, Minnesota, and northern Ontario to Manitoba and British Columbia (fig. 1).

## HABITAT CONDITIONS

Because of its wide distribution in the boreal and northern forest regions (19, 38), tamarack grows under extremely varied climatic conditions. These range from the continental climate (short, warm summers and long, cold, and rather dry winters) of interior Alaska and northern Canada to the oceanic climate (cool, and much more moist, with less temperature extremes) of Maine and the Maritime Provinces. The topography is characteristically level or only slightly rolling and the soils typically of organic origin and on the moist side.

### Climatic Factors

Average January temperatures within the range of tamarack vary from -22° to 30° F. and those of July from 55° to 75°. The lowest temperatures ever recorded range from -20° to -79°, the highest, from 85° to 110° (23, 24, 36, 41).

The annual precipitation is also extremely variable, fluctuating from 7 inches at Fort Yukon, Alaska, to 55 inches in eastern Canada. Of this, 3 to 14 inches fall in June, July, and August. Snowfall within the range of tamarack shows a similar wide variation: 30 inches in northern Minnesota, 40 inches in Saskatchewan and Manitoba, 50 inches in Alaska, 60 to 80 inches in Alberta and British Columbia, 100 inches in northern Michigan, and 160 inches in Newfoundland and Labrador (23, 24, 32, 36, 41).

The frost-free period averages in length from 80 to about 180 days in the southern part of the range of this tree but only from 75 to 120 days in interior Alaska. The short growing season in the northern latitudes is counterbalanced by much longer periods of daylight (15, 23, 24).

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5/ Commercial range is defined as that portion of the botanical range within which the species grows to commercial size and is a major or important species in the type.

## Physiographic Factors

Tamarack is a characteristic tree of bogs and swamps and at its southern limits of growth is usually confined to such situations. Farther north it also grows on much drier sites; scattered individuals and occasionally stands are found on swamp margins and the banks of streams and lakes and on low ridges and benches and other upland sites. At its northwestern limits (Alaska and British Columbia) tamarack is often an upland tree, being found on the moist cool north slopes of mountains as well as in the valley swamps (7, 35, 39).[6/] [7/]

Over most of the range, there is relatively little variation in elevation. In the Rocky Mountains and Alaska, however, the tree grows between 600 and 1,700 feet (40); in the eastern part of North America it occurs between sea level and 4,000 feet (45).

## Edaphic Factors

Few trees can tolerate as wide a range in soil moisture conditions as tamarack (44). Although the tree is most commonly found on the moist organic soils, peats and mucks, of swamps and muskegs, it will grow fairly well on soils that are extremely dry either because of shallow bedrock or a low water table.[8/] [9/] [10/] High water levels for short periods do not seem to affect tamarack growth adversely, but prolonged flooding will kill it. Nor does texture appear to be limiting, for the tree is found on soils ranging from stiff, heavy clay to coarse sand (45).

Its greater abundance on swampy lands probably is the result of an ability to withstand high soil moisture and acidity and low soil temperature better than can trees characteristic of surrounding upland

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6/ Grisez: See footnote 4, page 1.

7/ Correspondence with D. B. Cook, New York Conservation Department, April 24, 1956, on file at Lake States Forest Experiment Station.

8/ Correspondence with J. T. Curtis, Department of Botany, University of Wisconsin, May 4, 1956, on file at Lake States Forest Experiment Station.

9/ Correspondence with J. K. Childs, Division of Forestry, Minnesota Conservation Department, April 11, 1956, on file at Lake States Forest Experiment Station.

10/ Correspondence with D. W. MacLean, Forestry Branch, Canada Department of Northern Affairs and National Resources, March 27, 1956, on file at Lake States Forest Experiment Station.

sites; its best growth, however, is made on much more favorable situations.[11] These include rich, moist but well drained, loamy soils along streams, lakes, and swamps; seep areas; and shallow layers of muck or well decomposed peat over mineral soils (44, 45).[12]

Peat soils on which tamarack occurs are either one of two main types: woody peat and sphagnum peat. The former typically shows better decomposition, and averages higher in nitrogen and mineral nutrients than does sphagnum peat, and is less acidic in reaction (48). The tree is rare in the extensive limestone areas of the Gaspe Peninsula and Anticosti Island (30).

## Biotic Factors

Tamarack in the eastern United States occurs both in pure stands and in mixture with other trees. It is much more local in its occurrence there, however, than it is further west in the Lake States or in Canada where it forms pure even-aged stands, often of considerable extent.

The tree is a component, to the degree indicated, in the following cover types recognized by the Society of American Foresters in northern North America: tamarack (No. 38) dominant; black spruce-tamarack (No. 13) codominant; black spruce (Nos. 12 and 204) and black spruce-white spruce (No. 2), a common associate; black spruce-balsam fir (No. 7), balsam fir (No. 5), white spruce-balsam fir-aspen (No. 9), northern white-cedar (No. 37), and black ash-American elm-red maple (No. 39), a minor but rather constant associate (38).

The most common associates are: black spruce (Picea mariana), white spruce (P. glauca), balsam fir (Abies balsamea), jack pine (Pinus banksiana), northern white-cedar (Thuja occidentalis), quaking aspen (Populus tremuloides), balsam poplar (P. balsamifera), paper birch and its Kenai variety (Betula papyrifera and var. kenaica), yellow birch (B. alleghaniensis), black ash (Fraxinus nigra), red maple (Acer rubrum), and American elm (Ulmus americana) (15, 38, 40). Trees less commonly associated with tamarack are: red spruce (Picea rubens), eastern hemlock (Tsuga canadensis), eastern white pine (Pinus strobus), Atlantic white-cedar (Chamaecyparis thyoides), gray birch (Betula populifolia), American basswood (Tilia americana), black cottonwood

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11/ Correspondence with H. I. Baldwin, New Hampshire Forestry and Recreation Commission, February 27, 1956, on file at Lake States Forest Experiment Station.

12/ Unpublished data, Lake States Forest Experiment Station.

(Populus trichocarpa), black willow (Salix nigra), blackgum (Nyssa sylvatica), sassafras (Sassafras albidum), and red alder (Alnus rubra) (7, 11, 38, 40, 45).[13/]

Tamarack stands cast but light shade; consequently they have a dense understory of shrubs and herbs (7, 8). Shrubs associated with this tree include: American green alder (Alnus crispa), speckled alder (A. rugosa), downy andromeda (Andromeda glaucophylla), bogrosemary andromeda (A. polifolia), bearberry (Arctostaphylos uva-ursi), dwarf birches (Betula glandulifera and B. nana), bog birch (B. glandulosa), leatherleaf (Chamaedaphne calyculata), redosier dogwood (Cornus stolonifera), creeping snowberry (Gaultheria hispidula), checkerberry wintergreen (G. procumbens), black huckleberry (Gaylussacia baccata), common winterberry (Ilex verticillata), bog kalmia (Kalmia polifolia), labradortea (Ledum groenlandicum), crystaltea (L. palustre decumbens), sweetgale (Myrica gale), mountainholly (Nemopanthus mucronata), bush cinquefoil (Potentilla fruticosa), rhodora (Rhododendron canadense), poisonsumac (Toxicodendron vernix), meadowsweet spirea (Spiraea alba), lowbush blueberry (Vaccinium angustifolium), highbush blueberry (V. corymbosum), bog bilberry (V. uliginosum), cranberry (V. macrocarpum), small cranberry (V. oxycoccos), witherod viburnum (Viburnum cassinoides), American cranberrybush (V. trilobum) (11, 15, 16, 17, 20, 31).[13/]

Because of its extensive range, tamarack has a great variety of herb associates. None of these, however, are known to be characteristic of this tree alone. This is also true of the many birds and animals which occur in the boreal and northern forest regions. Animals affecting the life and development of tamarack are discussed in succeeding sections under factors affecting the growth of seedlings and larger trees.

## LIFE HISTORY

The development of tamarack from seed to mature trees follows a characteristic pattern governed by many inherent characteristics and environmental factors. In general terms tamarack is a very intolerant species chiefly confined to moist sites over a wide geographic area.

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13/ Grisez: See footnote 4, page 1.

## Seeding Habits

### Flowering and Fruiting

Both sexes of tamarack flowers are borne separately on the same tree in small strobiles. Staminate flowers occur mainly on 1- or 2-year-old branchlets; pistillate flowers occur most frequently on 2- to 4-year-old wood, and occasionally on 1-year-old twigs (young trees just producing seed) and on branchlets 5 to 10 or more years old. This seems to be related to rate of growth; vigorous trees apparently produce cones mainly on young wood. Cones are borne all over the crowns of open-grown trees (16).

Flowering occurs early, the two types of flowers maturing about the time leaf development begins. In Marquette County, Mich., 4 years of records show tamarack flowering from May 2 to May 9;[14/] in northeastern Minnesota flowering over a 5-year period ranged from April 25 to May 9.[15/] A limited amount of data from Marquette County, Mich., shows that cones began to form about June 20, completed ripening August 26, and began to open August 28.[14/]

At the more southern latitudes, cones ripen from mid-August to late September; seed fall begins soon thereafter, sometimes continuing into early winter (26, 40, 46). At Cloquet in northeastern Minnesota, 65 percent of 1 year's crop fell from September 1 to 20, 25 percent from September 20 to October 10, and the remaining 10 percent mostly before October 31 with a few released during the winter months (16). No data are available on seed ripening habits in Alaska and the Far North. The empty cones remain on the trees from 2 to 5 years (16, 44).

Tamarack seed crops are reduced by several agencies:

1. An undetermined species of Lepidoptera feeds on the developing seeds and sometimes destroys as much as 40 percent of the seed crop.[16/]

2. The red squirrel (Tamiasciurus hudsonicus) often cuts cone-bearing branchlets and caches the cones (16).

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14/ See footnote 12, page 5.

15/ Correspondence with C. Ahlgren, Quetico-Superior Wilderness Research Center, November 1956, on file at Lake States Forest Experiment Station.

16/ Howard A. Tripp. Reported as personal correspondence by Duncan 1954 (16).

3. The seeds are eaten by the American red crossbill (Loxia curvirostra) (16).

## Seed Production and Dissemination

Isolated trees in swamps and trees in upland plantations begin to bear viable seed as early as 12 to 15 years of age (16).[17/] Production in commercial quantities does not begin until about 40 years with optimum production at about 75 years (16, 46). Tamarack in swamps in Saskatchewan and Manitoba do not bear cones in appreciable quantity until the trees are about 50 years old (14).

Good seed crops are borne at intervals of 3 to 6 years, with some seed borne in intervening years (11, 16, 46). Cones from mature trees have been found to contain an average of 26 seeds, two-thirds of which are filled; cones from young trees average 39 seeds, 85 percent of which are sound (16).

The heaviest cone crops are borne by vigorous open-grown trees between 50 and 150 years old, with some cones produced until the age of 250 years. The former may bear as many as 20,000 cones per tree containing a total of over 300,000 sound seeds in a good year. In stands, seed production is confined mostly to the dominant and codominant trees. Open-stocked mature stands 80 years old, will produce 1,500,000 to 2,500,000 filled seeds per acre in a good year; closed stands of similar age will produce 500,000 to 1,200,000 seeds. Probable production of a medium-stocked stand in a bumper year is about 5,000,000 germinable seeds per acre (16).

Seed are dispersed for rather short distances; very few fall at a distance greater than twice the tree height (16).

Tamarack seeds are small, averaging 318,000 per pound cleaned (range 210,000 to 420,000). Many seeds are empty or only partially filled; the average soundness is only 49 percent. The seed keeps, with little loss in viability, for at least 5 or 6 years if stored at a low moisture content in sealed containers at about 40° F. (46).

Little is known of the effects of climatic and biotic factors on flowering and fruiting of tamarack. Some cones were still being produced after 3 or 4 years' defoliation by the larch sawfly in Saskatchewan and Manitoba, and after 8 years of attack by this insect in northern Minnesota (14).[17/]

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17/ See footnote 12, page 5.

## Vegetative Reproduction

Layering, although uncommon in tamarack, sometimes occurs where branches are covered by fast-growing sphagnum moss or by drifting sand (3, 16). Roots are also known to send up shoots, which presumably can develop into trees; a case has been reported from Alberta of a 32-foot root that had 11 sprouts about a foot high attached at various points along its length (27).

## Seedling Development

### Establishment

Tamarack seed has internal dormancy and will not germinate well unless kept moist for a period at cold temperatures. In nature, such dormancy is broken while the seed lies on the ground during the first winter, germination taking place the following spring (46).[18/]

Germination begins from late May to mid-June and reaches a peak when the soil surface has a temperature of about 65° to 70° F. Germination begins earlier on unshaded ground than under cover. Judging from laboratory experiments, germination will occur at a constant soil temperature as low as 60°, its rate increasing with temperature, at least up to about 75°. Under the shade of northern white-cedar, it will occur at 55°. (16)

Tamarack seeds need a good supply of moisture for germination, but they will not germinate under water as might be expected of a swamp tree (16). Neither light nor pH seem to play any important role in germination (16). The seedlings need some shade during early life, both in the forest and in the nursery (40, 45, 46). Too much overhead or low cover, however, will prevent seedling establishment (11).

The best seedbed is moist mineral or organic soil free of brush but with a light cover of herbs or grass (5, 39). Hummocks of sphagnum moss, particularly of the slower growing species, also make a good seedbed if free of labradortea and subject to neither flooding nor drying out (5).[18/] [19/] In a study in Minnesota, the best field germination was obtained on the fine-textured mosses, Mnium, Drepanocladus, and Helodium (16).

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18/ Correspondence with D. P. Duncan, School of Forestry, University of Minnesota, March 19, 1956, on file at Lake States Forest Experiment Station.

19/ See footnote 12, page 5.

Although the best silvicultural system for tamarack has not yet been demonstrated, some form of clear cutting would seem to be the answer. Where practicable, control of the water level of swampy sites to reduce mortality from flooding or from drought probably would prove beneficial, at least in the regeneration stage. (16)

Early Growth

Tamarack seedlings need abundant light and a relatively constant water level for survival and best growth. Those coming in under the shade of fully stocked stands grow very slowly, averaging only about an inch in height at the end of the first year, and do not survive beyond the sixth year (16). Where there is little or no cover, growth is much better and survival is good; the seedlings reach a height of as much as 7 to 9 inches the first year and 18 to 25 inches by the third year (8). From then on, they grow rapidly, provided there is full light and good drainage. In the cold swamps and muskegs of northwestern Canada, however, growth is very slow, the seedlings that become established making only ½ to 2 inches of height growth per year for the first 8 years (5).

Swelling of tamarack leaf buds begins about 2 or 3 weeks before they actually open, long before the frost is out of the ground; in northeastern Minnesota, this occurs from April 6 to 23.[20/] Emergence of the needles averages April 12 at St. Paul, Minn. (10-year records (21)), and May 8 in Marquette County, Mich.[21/] and in Saskatchewan (43). It ranges from April 21 to May 26 in northeast Minnesota.[20/] Foliage development is rather slow; it requires about 6 weeks for the trees to reach full leaf (10). Leaf coloring begins September 8 in Marquette County, Mich., and is at maximum development on October 5 (Michigan) to October 8 (northeastern Minnesota[20/ 21/]). Tamarack is the last of the northern deciduous trees to lose its leaves; this occurs over a period ranging from September 10 to October 18.[20/ 21/]

Height growth apparently does not begin until the first needles have reached full development. In eastern New York on an upland plantation, the average date on which height growth began was May 28; it continued until September 1, a period of 96 days (10). In Marquette County, Mich., 9-year records show the corresponding dates to be May 24 and August 14.[21/] The beginning of diameter growth, as indicated by stem expansion, ranges from April 6 to June 8 and cessation of diameter growth from July 29 to August 6 in northeastern Minnesota.[20/]

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20/ Ahlgren: See footnote 15, page 7.
21/ See footnote 12, page 5.

The tree typically has a shallow but compact root system which, on favorable sites, may spread over an area greater in radius than the height but only 1 or 2 feet in depth. No taproots are formed by swamp tamaracks (5, 11). Trees on sandy upland show a "plate-like" rooting habit; few roots reach below a depth of 1 foot and taproots are rare (2). On wet land, tamarack roots usually are stringy with no branches for about 6 inches back from the tips; branchlets carry mycorrhizae (5, 11). As the moss layer deepens in swamps, the trees will develop new roots from the stem above the original root collar; when this occurs the old roots almost cease growth (5). On somewhat drier soils, the roots of larger trees bend sharply away from the trunks, forming "knees" which were used for ribs in the days of wooden ships (45).

## Factors Limiting Seedling Development

Because of their small size, tamarack seedlings are very easily killed during the first 6 or 8 weeks of life. Damping-off causes most of the loss, followed by mechanical injury, drought, drowning, and insects such as larvae of the larch sawfly (Pristiphora erichsonii). Drought and drowning, together with inadequate light, may cause appreciable loss even in the second and third years. One-year-old seedlings grown in full light can survive drying of the surface inch of soil down to about 4 percent by volume or 45 to 65 percent by weight in peat soils. Most of such seedlings, however, will die if completely submerged for 3 or 4 weeks. Forest-grown seedlings 1 to 3 years of age are even less able to withstand flooding and drought (16).

Nipping by snowshoe hares (Lepus americanus) causes heavy loss of seedlings in some areas (5, 47).

## Sapling Stage to Maturity

Tamarack in stands (fig. 2 on following page) characteristically forms a straight slender tree, which has a narrow, somewhat pyramidal crown composed of small, short branches (see cover picture). Open-grown trees have branches that are larger, somewhat drooping, and extend well toward the ground. In forest-grown trees, however, the crown is short, occupying only from one-third to one-half the length of the bole (35, 40, 45). The bark is thin, being only 1/2 to 3/4 inch thick at the base of the trunk of mature trees (35).

Figure 2.--A well-stocked, 48-year-old stand of tamarack in northeastern Minnesota.

## Growth Rate and Sizes Attained

The growth rate of established tamarack saplings appears to depend largely on moisture conditions. In wet stagnant swamps, the tree grows very slowly, reaching an average height of as little as 6 feet in 55 years.[22/] On well drained sites, on the other hand, it is one of the fastest growing of the conifers characteristic of the boreal forest and by far the fastest growing of the swamp species (8, 34). In Alberta, good-site tamarack will maintain height growth averaging 1.5 feet for 20 to 30 years. When the crowns close, however, growth drops to a very low level (5).

In northern Ontario, the tree grows well on 3 or more feet of peat, provided that the zone of continuous saturation is at least 18 inches below the surface of the swamp. If given ample growing space in such swamps, tamarack will outgrow black spruce.[23/]

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22/ See footnote 12, page 5.
23/ MacLean: See footnote 10, page 4.

The following figures on the height and d.b.h. (diameter at breast height) of tamarack at various ages give some idea of its growth (11):

| Age | Height | D.b.h. |
|---|---|---|
| 5 | 3 | 1/- |
| 8 | - | 1.0 |
| 11 | - | 2.5 |
| 15 | 16 | - |
| 20 | - | 7.5 |
| 25 | - | 8.5 |
| 30 | 44 | - |
| 45 | 60+ | 18.0 |

1/ Dash (-) indicates no data.

The height of mature trees averages 50 to 75 feet with occasional individuals reaching 100 to 115 feet (11, 30, 45). Diameters of mature trees vary from 14 to 20 inches with a few reaching 36 to 40 inches (11, 30, 35). Both height and diameter apparently decrease in the northern part of the tamarack range, mature timber in northwestern Alberta averaging only 40 to 50 feet in height and 12 inches d.b.h. at 80 to 95 years (31). In northwestern Alaska, mature tamarack often is only 10 feet high and 3 inches in diameter. Trees 60 to 80 feet high and 20 to 24 inches in diameter were once common in the Lake States (39). The tree probably reaches its best development in the area north of Lake Winnipeg (35).

Little information is available on the yield of tamarack stands. On the basis of 7-year records taken on permanent sample plots in northern Minnesota, well-stocked tamarack 70 to 100 years old on swamp sites made an average growth of 0.57 cord and poorly stocked stands 0.28 cord per acre per year on basal areas of 93 and 35 square feet per acre respectively.[24/] Stands are usually even aged.

The tree is of moderately long life. Sudworth (40) gives the maximum age as 150 to 180 years. However, trees have been found on Isle Royale in Lake Superior that were 230 to 240 years of age, with one individual 335 years old (12). This is by far the oldest tamarack on record.

24/ See footnote 12, page 5.

## Reaction to Competition

Tamarack is a very intolerant tree. It can stand a small amount of shade during the first 3 or 4 years, but then must become dominant or it will die (1, 16, 45). When in mixture with other species, it must be in the overstory to survive (45). The tree is an excellent self-pruner, the trunks after the first 25 to 30 years being clear of branches for one-half or two-thirds of their length (39).

## Place in Succession

In the Lake States and probably throughout most of its range, tamarack is generally the first forest tree to invade swamps in the sphagnum, sedge mat, or bog shrub stages (9, 12, 17). Because of its great degree of intolerance and likely also because of the dense vegetation which develops underneath its stands, tamarack is not able to reproduce under its own shade. The only tree associates that can do so are the more tolerant black spruce, northern white-cedar, balsam fir, and some of the swamp hardwoods. As a result, these species eventually succeed tamarack--black spruce on poorly drained acid peat, and white-cedar, balsam fir, and swamp hardwoods, more or less in the order named, on the better drained, less acid, and more fertile swamps (38).[24/]

## Factors Limiting Growth and Survival

Tamarack has relatively few enemies; the more important of these, however, may cause considerable injury or loss of trees in the sapling to mature stages:

1. Tamarack on upland sites is quite resistant to fire except in the seedling stage. In swamps, however, because of its shallow rooting habit, the tree is usually killed by fire unless the burn is very light (5, 8).

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24/ See footnote 12, page 5.

2. Abnormally high water levels often kill established tamarack stands. Other stands have developed under such wet conditions that submergence of the roots, while not killing the trees, reduces growth to a minimum (45). Flooding is very often the result of beaver (Castor canadensis) activity.

3. Strong winds will often uproot large tamarack trees growing in swamps or other wet sites where rooting is characteristically shallow.

4. The larch sawfly, a pest probably introduced from Europe, periodically becomes epidemic and defoliates tamarack stands over hundreds of square miles for several successive years, greatly reducing growth and causing heavy mortality. The last destructive outbreaks of this pest occurred in the Lake States from 1909 to 1926 and in the Northeast in the 1880's. This insect has been in epidemic stage in Minnesota and adjacent Canada for about 10 years. Its numbers have been increasing in northern Wisconsin and Michigan since 1953.

   In this present outbreak, tree mortality became evident on the poorer sites in northeastern Minnesota after 7 years of heavy defoliation and in the near-merchantable stands on the better sites in north central Minnesota after 8 years of heavy feeding. The earlier epidemic, however, killed most of the larger tamarack over a wide territory in the northern part of the Lake States, and it has taken about 40 years for the tree again to become of economic importance. Although the trees do not usually die until they have been heavily defoliated for about 7 years (4, 42), the present outbreak threatens to cause heavy loss, for it has been at serious proportions for several years and shows no sign of abating. The sawfly defoliates isolated trees as readily as those in stands.[24/]

5. The larch case bearer (Coleophora laricella) another insect native to Europe, has become widely distributed in the Northeast and the Lake States and adjacent Canada. It causes the tips of the needles to become brown in late May and early June. Serious defoliation not only reduces growth but when continued for 2 years or more also causes considerable mortality (13).

6. The eastern larch beetle (Dendroctonus simplex) sometimes attacks and kills tamarack trees weakened by sawfly attack, fire scorching, and flooding (37).[24/]

7. The white-marked tussock moth (Hemerocampa leucostigma) sometimes defoliates tamarack in eastern Canada (33).

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24/ See footnote 12, page 5.

8. Tamarack in the Lake States and doubtless elsewhere over its range is sometimes affected by heartrot (caused by Fomes pini), butt rot (from attack by Polyporus schweinitzii), or root rot (caused by Armillaria mellea). However, the decay caused by these fungi is apparently less important in this species than it is in other conifers (29).

9. Planted tamaracks growing in New England have been successfully inoculated with the fungus, Dasyscypha willkommii, which causes canker in European (Larix decidua) and other larches. This fungus, however, has never been found in natural stands (18).

10. Tamarack is occasionally attacked by the dwarf mistletoe (Arceuthobium pusillum) causing the formation of witches'-brooms (25).

11. The porcupine (Erithizon dorsatum) feeds on the inner bark of tamarack, often stripping the upper stem of the tree to a very small diameter and causing a great amount of deformation. Other trees are girdled below the crown and are thus killed. Few stands of tamarack that have escaped the depredation of this pest can be found in the Lake States. Stands covering as much as 8 to 10 acres are known where nearly every tree shows some sign of porcupine injury.[24/] The animal is also a serious enemy of tamarack in Maine.[25/]

12. White tailed deer (Odocoileus virginianus) occasionally browse the twigs of saplings.[24/]

## SPECIAL FEATURES

Tamarack has hard, coarse-grained, resinous wood which is intermediate in strength and in decay resistance. Its major uses are for pulpwood, mine timbers, and fence posts and other farm construction. Although a rather large amount was once used for lumber and railroad ties, the accessible sawtimber stands were largely wiped out by the sawfly about 40 years ago. Hence only small quantities of tamarack are now cut for these purposes. (6)

On the basis of casual observation, the tree seems to be resistant to foliage sprays containing the herbicides 2,4-D and 2,4,5-T.[24/]

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24/ See footnote 12, page 5.
25/ Grisez: See footnote 4, page 1.

## RACES, HYBRIDS, AND OTHER GENETIC FEATURES

No specific races have yet been recognized in tamarack. However, considering the great range in latitude and longitude over which this species occurs, races probably do exist. A variety of tamarack, L. laricina var. alaskensis, has been recognized by some botanists (others call it a separate species, L. alaskensis). Further study may prove this variety to be a separate race.

Artificial crosses with European larch have been produced in Denmark; that in which tamarack is the female parent was named x Larix pendula (22).

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This is the sixth of the 15 silvical reports being prepared by the Lake States Forest Experiment Station.

Already published are reports on:

Red pine - Station Paper 44
Black spruce - Station Paper 45
Rock elm - Station Paper 47
Quaking aspen - Station Paper 49
Sugar maple - Station Paper 50

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Basswood
American elm
Slippery elm
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Jack pine
Balsam poplar
White spruce
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